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**HMT ASSOCIATES, L.L.C.**

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June 3, 2003

Mr. James Enoch Jones  
Director  
Office of Hazardous Materials  
Exemptions and Approvals (DHM-30)  
Department of Transportation  
Washington, D.C. 20590-0001

Re: **Application for Emergency Exemption**

Dear Mr. Jones:

Pursuant to the provisions of 49 CFR 107.105 and 107.117, and on behalf of Bowgen Fuel Systems, Inc., of Springfield, Missouri, this is to request an emergency exemption from the provisions of the Hazardous Materials Regulations ("HMR", 49 CFR Parts 171-180). The requested exemption would authorize the manufacture, mark, sale and use of a motor vehicle (trailer) with horizontally mounted and secured, manifolded, non-DOT specification fiber reinforced plastic hoop wrapped cylinders for the transportation in commerce of compressed natural gas. The information below is submitted in accordance with §§ 107.105 and 107.117.

1. **Regulations From Which Relief Sought.** 49 CFR §§ 173.302 and 173.302a, in that the use of a non-DOT specification cylinder would be authorized for the transport of compressed natural gas (CNG).
2. **Applicant.** HMT Associates, L.L.C., on behalf of Bowgen Fuel Systems, Inc. ("Bowgen"), 3392 South Bowgen Parkway, Springfield, Missouri 65807; contact: Mr. Len Bowgen, telephone: (417) 887-4773. Please address any questions concerning this application to the undersigned at the address and telephone number indicated in the letter head.

HAZMAT  
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3. **Description of Proposal.** The applicant requests that an emergency exemption be issued that would permit the manufacture, mark, sale and use of a motor vehicle (trailer) with horizontally mounted and secured, manifolded, non-DOT specification fiber reinforced plastic hoop wrapped cylinders for the transportation in commerce of compressed natural gas. To provide for an equivalent level of safety in transport, the applicant proposes that the conditions and limitations outlined below be incorporated into the requested exemption.

*Packaging Prescribed.* It is proposed that the requested exemption prescribe use of a motor vehicle (trailer) with horizontally mounted and secured, manifolded, non-DOT specification fiber reinforced plastic hoop wrapped cylinders, and meeting the following requirements:

A. *Cylinders.* Cylinders authorized would be non-DOT specification fiber reinforced plastic (FRP) hoop wrapped (HW) cylinders manufactured by Pressed Steel Tank Company, Inc., of Milwaukee Wisconsin. Cylinders would be in full compliance with DOT FRP-2 Standard, Revision 1, dated January 4, 1987 (§ 178.BB, copy enclosed) as modified by paragraph 7.a. of DOT-E 8965 (copy enclosed), except as follows:

1) § 178.BB-3 Inspection by whom and where. Inspections and verifications would be as provided in § 178.BB-3 (which is not modified in DOT-E 8965), except that chemical analyses of steel may be verified by the independent inspection agency on the basis of ladle analysis provided by the Canadian manufacturer of the steel.

2) § 178.BB-6 Manufacture. Manufacture would be as provided in § 178.BB-6, as modified by paragraph 7.a. of DOT-E 8965, except as follows (Note: Paragraph references correspond to those in § 178.BB-6.):

(a) Liner. Liner without overwrap would be suitable for marked service pressure of at least 47.7 percent of the service pressure marked on the composite cylinder, and would be in full compliance with DOT 3AA (§ 178.37) except as follows:

(1) The design would be required to be in compliance with § 178.37(a)(2);

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(2) \* \* \*

(3) The flattening test in § 178.37(j) would not be required.

(b) Composite cylinder. Autotfrettage by pressurization would not exceed 125 percent of the prescribed minimum test pressure. [Remainder of § 178.BB-6(c) would be as prescribed in DOT-E 8965].

(d) Lot size. Lot size would be as prescribed in § 178.BB-6(d)(1) (which is not modified in DOT-E 8965), except that (d)(1)(i) and (d)(2)(i) would allow liners and cylinders, respectively, in the same lot to be of varying lengths.

3) § 178.BB-11 Nondestructive tests. Nondestructive tests would be as prescribed in § 178.BB-11 (which is not modified in DOT-E 8965), except that *in addition to* the hydrostatic test prescribed in this section, each cylinder would be subject to the following test (which may be identified as § 178.BB-11(b)):

“(b) Ultrasonic test. The entire wall (i.e., 100 percent) of each cylinder must be ultrasonically tested.”

4) § 178.BB-12 Destructive tests. Destructive tests would be as provided in § 178.BB-12, as modified by paragraph 7.a. of DOT-E 8965, except that in the burst test (§ 178.BB-12(b), which is not modified in DOT-E 8965) the minimum prescribed burst pressure would *not* be held for 60 seconds prior to increasing pressure to failure.

5) § 178.BB-13 Acceptable results of tests. Acceptable results of tests would be as provided in § 178.BB-13, as modified by paragraph 7.a. of DOT-E 8965, except as follows (Note: Paragraph references correspond to those in § 178.BB-13.):

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(b) Physical test. Physical tests would be as prescribed in § 178.BB-13(b) (as modified by DOT-E 8965), except that *in addition to* the tests prescribed in this paragraph, the following test would be required (which may be identified as § 178.BB-13(b)(4)):

“(4) Charpy impact value at -40°F must be not less than 44 J/cm<sup>2</sup>.”

(c) Cycling test. The cycling tests would be as prescribed in § 178.BB-13(c), as modified by DOT-E 8965, except that the phrase “10,000 pressurizations between approximately zero and service pressure” would be replaced by the phrase “5,000 pressurizations between approximately zero and 1.25 times the service pressure”.

(e) Ultrasonic test. A new paragraph (e) would be added to § 178.BB-13 to provide the acceptable results for the additional ultrasonic test, to read as follows:

“(e) Ultrasonic test. In no case may the notch size of any longitudinal defect exceed 0.015 inches deep by 0.75 inches long, or for any transverse defect exceed 0.025 inches deep by 0.75 inches long.”

6) § 178.BB-15 Marking. Marking of cylinders would be as prescribed in § 178.BB-15, which is modified by DOT-E 8965 only by replacing the word “aluminum” wherever it appears with the word “steel”, except that the DOT exemption number would not be permanently marked on each cylinder.

7) § 178.BB-16 Inspector’s report. Inspector’s report would conform to the report requirements in ANSI Standard NGV2-2000 (“Basic Requirements for Compressed Natural Gas Vehicle Fuel Containers”).

8) § 178.BB-18 Design qualification tests. Design qualification tests would be as provided in § 178.BB-18, as modified by paragraph 7.a. of DOT-E 8965, except as follows (Note: Paragraph references correspond to those in § 178.BB-18.):

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(b) Design changes. Paragraph § 178.BB-18(b) (which is not modified in DOT-E 8965) would apply except that in subparagraph (b)(2) the allowable percent change in diameter would be “20 percent”.

(d) Pressure cycling tests. The pressure cycling tests would be as prescribed in § 178.BB-18(d), as modified by DOT-E 8965, except that in subparagraph (d)(2)(iv) the value “-60° F” would be replaced by the value “-40°F” and sub-paragraph (d)(1) would be revised to require:

“(1) Cycling test at ambient temperature. One representative cylinder shall be cycle tested at ambient temperature without showing evidence of distortion, deterioration or failure, as follows: pressurize from approximately zero to 1.25 times service pressure for 5,000 cycles; then pressurize from approximately zero to service pressure for 13,000 cycles. After successfully passing this test the cylinder must be pressurized (cycled) from approximately zero to 1.25 times service pressure until the cylinder fails. Failure must be by leakage rather than burst, and the failure pressure must be recorded.”

(e) Hydraulic burst test. The hydraulic burst test would be as prescribed in § 178.BB-18(e), as modified by DOT-E 8965, except that in subparagraph (e)(1) the words “this pressure to be held for 60 seconds” would be removed.

**NOTE:** To illustrate the conditions and limitations proposed to be applicable to the cylinders to be used under the requested exemption, a draft of the “Packaging” section of the exemption (typically Paragraph 7.a. of the exemption) is enclosed for your information and review. Comparison of this draft with the corresponding paragraph 7.a. of DOT-E 8965 will facilitate identification of the relatively minor differences between the cylinders authorized under that exemption and those for which authorization for use is requested in this application. An electronic version of the enclosed draft paragraph 7.a. of the exemption will be provided to you upon request.

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B. *Motor vehicle (trailer).* Authorized cylinders would be horizontally mounted on a motor vehicle (trailer), secured, manifolded together, and valves and pressure relief devices protected, in conformance with all applicable requirements in § 173.301(g)(1) of the HMR.

C. *Testing.* Authorized cylinders would be required to be reinspected and hydrostatically retested in accordance with §§ 180.205 and 180.209 as required for DOT 3HT cylinders, except that maximum requalification period is 5 years and that the rejection elastic expansion criteria would not apply. Instead, permanent volumetric expansion would not be permitted to exceed 5 percent of total volumetric expansion at test pressure. Marking of test dates on cylinders would be as prescribed in paragraph 7.b. of DOT-E 8965.

*Operational Controls and Special Provisions.* It is proposed that the following Operational Controls and Special Provisions be incorporated into the requested exemption:

A. Cylinders permitted under the exemption would no longer be authorized for use 15 years from the date of manufacture of the cylinder.

B. In accordance with the provisions of § 173.22a(b), persons would be authorized to use the packaging authorized by this exemption for the transportation of the hazardous material specified in paragraph 4, below, only in conformance with the terms of the requested exemption.

C. A current copy of the exemption would be required to be maintained at each facility where the package is offered or reoffered for transportation.

D. A current copy of the exemption would be required to be carried on each motor vehicle transporting hazardous materials under the terms of the exemption.

4. **Hazardous Material to be Transported.** It is requested that the following hazardous material be authorized for transport under the terms of the exemption:

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Hazardous materials description -- proper shipping name	Hazard Class/ Division	Identi- fication number	Packing Group
Methane, compressed, <i>or</i> Natural gas, compressed, ( <i>with high methane content</i> )	2.1	UN 1971	N/A

5. **Transport Modes.** Authorization is sought for transportation by motor vehicle only. No modal-specific safety control measures (in addition to those proposed above) are considered necessary.

6. **Duration of Exemption.** It is requested that this exemption be issued for a renewable, two year period.

7. **Justification for Exemption and Level of Safety.** For the reasons offered below, the applicant submits that the exemption requested herein is justified in that the provisions proposed above will achieve an appropriate level of safety in the transport of the hazardous material concerned, and one which is commensurate with the level of safety provided in the transport of CNG in the similar cylinders authorized under DOT-E 8965.

Background information and nature of the existing emergency. The trailers for which exemption is requested are used by natural gas utility companies to ensure service is maintained to residential customers, small subdivisions, pipelines, businesses and master metered complexes during gas line repairs. When a service interruption is anticipated due to the need to shut down and repair a gas distribution line, one of these trailers is spotted and connected to the distribution line below the point at which the repair is to be made. The gas from the trailer is then used to supply the customers until the necessary line repair is effected and normal service through the distribution line restored. Approximately 14 trailers have been delivered to various gas utility companies by Bowgen to be used for this purpose.

The composite cylinders to be used on the trailers concerned were purchased from Pressed Steel Tank Company, Inc., of Milwaukee, Wisconsin - the manufacturer of the cylinders. At the time of purchase, Bowgen did not recognize that - while the cylinders conform to ANSI Standard NGV2-

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2000 and are authorized under National Highway Traffic Safety Administration's (NHTSA) standards for use as fuel tanks on CNG-powered vehicles - the cylinders were not, necessarily, authorized for use in the transport of CNG "in commerce". In an effort to ascertain whether the cylinders concerned could be used for this purpose, Bowgen contacted the cylinder manufacturer and based on an exchange of information between a PST employee (no longer with that company) and Bowgen late last year, Bowgen had understood that the cylinders concerned were authorized for use in the transport of CNG in commerce pursuant to the provisions of DOT-E 8965. However, Bowgen subsequently was advised that the cylinders were not covered by that exemption, or otherwise authorized for use in the transport of CNG in commerce by the HMR. Bowgen subsequently informed its customers that purchased trailers fitted with the cylinders concerned to remove the trailers from service until further notice.

In light of the foregoing, Bowgen respectfully requests that this application for exemption be processed on an emergency basis in order to allow the trailers concerned to be returned to service as soon as possible.

Level of safety achieved. For the reasons offered below, the applicant believes that the requested exemption will afford the necessary level of safety in the transport of the hazardous materials concerned.

*Proposed packagings.* The packaging for which authorization for use is requested in this application is a motor vehicle (trailer) with horizontally mounted and secured, manifolded, non-DOT specification fiber reinforced plastic hoop wrapped cylinders. As proposed in this application, the non-DOT specification cylinders would be mounted on the motor vehicles and manifolded in accordance with the applicable requirements of § 173.301(g)(1) of the HMR.<sup>1/</sup> This being the case, it is considered that the main technical and safety issues that may arise in connection with this application relate to the design, construction, qualification and periodic requalification of the non-DOT specification cylinders to be employed under the requested exemption.

As stated above, the cylinders concerned are manufactured by the Pressed Steel Tank Company, Inc. ("PST") of Milwaukee, Wisconsin. The cylinders fully conform to the requirements

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<sup>1/</sup> As amended by the Docket No. HM-220D final rule (see 57 FR 51626 and 68 FR 24653), this paragraph now permits the manifolding of non-DOT specification cylinders.



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of ANSI Standard NGV2-2000 ("Basic Requirements for Compressed Natural Gas Vehicle Fuel Containers"). Cylinders conforming to this standard are authorized by DOT's National Highway Traffic Safety Administration (NHTSA) for use as the fuel tanks on CNG-powered vehicles, including on the busses used by many municipalities. Clearly, this is a very demanding environment in that the cylinders are exposed to extreme environmental conditions, many (perhaps more than once daily) pressurization cycles over a period of many years, and the potential for mechanical damage. Cylinders conforming to ANSINGV2-2000 have been used safely in this very rigorous and demanding service for many years, and, although RSPA does not recognize this standard for purposes of transportation of CNG in commerce, experience in the use of cylinders conforming to this standard as fuel containers on CNG-powered vehicles demonstrates the safety afforded by such cylinders in the transportation environment.

PST is the holder of DOT-E 8965, which authorizes the use of composite, non-DOT cylinders (similar to those for which exemption is sought herein) for the transportation of CNG (and other gases) in commerce. DOT-E 8965 requires that the composite cylinders authorized conform to DOT FRP-2 Standard, Revision 1, dated January 4, 1987 (§ 178.BB), except as that standard is modified by paragraph 7.a. of the exemption. By issuance of that exemption, RSPA, in effect, has determined that the cylinders authorized under DOT-E 8965 ensure an equivalent level of safety in the transport of CNG in commerce to that afforded under the regulations from which exemption is granted. As stated above, the cylinders for which exemption is requested in this application - with only relatively minor differences - also conform to DOT FRP-2 Standard, Revision 1, dated January 4, 1987 (§ 178.BB), as that standard is modified by paragraph 7.a. of DOT-E 8965. *Indeed - and apart from the minimum requirements of ANSI NGV2-2000 - the materials of construction, construction techniques and design of the cylinders for which authorization for use is requested in this application are not changed materially from those employed by PST in the manufacture of the cylinders authorized under DOT-E 8965.* For this reason, the applicant submits that the cylinders for which exemption is requested herein, similarly, will ensure a level of safety in the transport of CNG in commerce that is equivalent to that afforded under the regulations from which exemption is requested.

To facilitate evaluation of the impact of the relatively minor differences between the cylinders authorized under DOT-E 8965 and those for which exemption is requested, a draft of paragraph 7.a. ("PACKAGING") of the requested exemption - based on the conditions and limitations proposed herein - has been prepared and is enclosed herewith. In comparing this draft

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paragraph to the corresponding paragraph 7.a. in DOT-E 8965, it is evident that many of the differences are very minor and would not adversely impact the safety of the cylinders for which exemption is requested as compared to the safety afforded by the cylinders authorized under DOT-E 8965. Indeed, some of the differences result in the application of more stringent requirements than are imposed under DOT-E 8965. The following is offered in explanation of certain of the differences between the cylinders for which exemption is requested and those authorized under DOT-E 8965.

- 1) Inspection by whom and where. ANSI NGV2-2000 (to which the cylinders were constructed) does not require chemical analyses of steels to be performed within the United States. However, for the cylinders concerned, the DOT inspection agency verified the correct material composition by use of the ladle analysis provided by the Canadian manufacturer of the steel used in the liners. This procedure is considered adequate to ensure the necessary control over the steel used in the liners.
- 2) Manufacture. The slight reduction in the suitable service pressure of the liner (i.e., 47.7 percent, as compared to the 50 percent prescribed in DOT-E 8965) is so small as to not materially affect safety in transport when viewed in the context of all other requirements (including tests) that would be imposed on the cylinders. Unlike the liners authorized under DOT-E 8965, the liners of the cylinders for which exemption is requested were not subjected to the flattening test in § 178.37(j). However, additional requirements proposed herein - including Charpy impact testing, full ultrasonic testing of walls, and more stringent cyclic design qualification burst testing - are considered to more than compensate for this difference and will ensure the necessary level of safety in the use of the cylinders for which exemption is requested.

In addition, a minor difference would exist in the definition of "lot size" (see proposed § 178.BB-6(d)) in that the requested exemption would allow cylinders of differing lengths to be considered to be of the same lot. Provided that all other defining parameters remain the same as prescribed in DOT-E 8965, allowing cylinders of slightly differing lengths to be considered to be of the same lot would not appear to reduce the level of safety achieved in the examination of representative cylinders from a "lot" as proposed to be defined in the requested exemption.

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3) Nondestructive tests. Unlike the cylinders authorized under DOT-E 8965, the cylinders for which exemption is requested would each be required to be subjected to 100 percent ultrasonic testing and be found free of disqualifying defects (see § 178.BB-11). This additional test (as compared to DOT-E 8965) will further ensure that the cylinders for which exemption is requested will afford the necessary level of safety in transport.

4) Acceptable test results. Unlike the cylinders authorized under DOT-E 8965, the steel used in the liners of cylinders for which exemption is requested would be required to exhibit a Charpy impact value at -40°F of not less than 44 J/cm<sup>2</sup> (see proposed § 178.BB-13(b)(4)). This additional physical test (as compared to DOT-E 8965) will further ensure that the cylinders for which exemption is requested will afford the necessary level of safety in transport.

In the cycling test it is proposed that cylinders be subjected to 5000 cycles, but pressurized to not less than 1.25 times the service pressure. While this is only half of the cycles required under DOT-E 8965, the pressure to which the cylinders must be pressurized is significantly higher. In light of the fact that cylinders in the service as described in this exemption application would never be expected to see 5000 pressure cycles within their authorized maximum 15 year service life, the proposed cycling test is considered adequate to ensure the necessary level of safety in the service for which authorization for use is requested.

5) Marking. It is proposed in this application that cylinders be required to be marked in the same manner as prescribed in DOT-E 8965 except that the DOT exemption number would not be required to be marked. Since many of the cylinders concerned have already been fabricated, it is not feasible at this time to permanently mark the DOT exemption number. At the same time, however, all other relevant safety information would be marked on the cylinders. Indeed, it is considered inappropriate to mark the exemption number on the cylinders in that the exemption covers the motor vehicle in which the cylinders are installed and not the individual cylinders themselves. Marking of the DOT exemption number on the cylinders concerned may incorrectly imply that the cylinders are authorized for use individually under the requested exemption - which would not be the case. The serial number required to be marked on each cylinder should be sufficient to allow identification

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of cylinders as having been manufactured to the requirements imposed under the requested exemption.

6) Inspector's report. It is proposed in this application that the inspector's report be permitted to conform to the requirements of ANSI Standard NGV2-2000 (the basic standard under which the cylinders were manufactured and inspected), rather than the specific form prescribed in § 178.BB-16 of DOT FRP-2 (as required under DOT-E 8965). This is considered to be acceptable in that the report will contain all essential information prescribed in § 178.BB-16, although the exemption number would not appear and the information would be presented in a different format. A representative example of the NGV2-2000 inspector's report prepared by the DOT-approved inspection agency for the cylinders concerned will be provided upon request.

7) Design qualification tests. The proposed ambient temperature cycling test (see proposed § 178.BB(d)(1)) is significantly more stringent than the corresponding test required under DOT-E 8965 in terms of both the total cycles required (18,000) and the pressure required to be achieved (1.25 times service pressure for the first 5000 cycles). Moreover, the test proposed herein, unlike the corresponding test authorized under DOT-E 8965, would require cylinders to fail by leakage rather than bursting. This more stringent test (as compared to DOT-E 8965) will further ensure that the cylinders for which exemption is requested will afford the necessary level of safety in transport.

The proposed use of -40°F in place of the -60°F minimum temperature to be achieved in the environmental cycling test is not considered to adversely affect the level of safety that would be achieved under the requested exemption as compared to that established by the corresponding test required under DOT-E 8965. The proposed -40°F temperature is equal to or lower than the temperatures prescribed elsewhere in the HMR for purposes of engineering design requirements for hazardous materials packagings - for example, in the case of portable tanks authorized for the transport of gases - and is representative of the lowest ambient temperatures encountered in the continental United States.

*Proposed periodic testing and inspection.* This application proposes that periodic inspection and hydrostatic retesting of cylinders be performed in the same manner as is required under DOT-E 8965 (see paragraph 7.b. of DOT-E 8965), except that the maximum requalification period

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prescribed would be five years. This slightly extended requalification period is considered appropriate for the exemption requested for several reasons. First of all, because of the manner in which the cylinders are manifolded, secured and protected within the motor vehicle as would be required by the requested exemption, the possibility of mechanical damage (such as would be expected in the handling of "loose" cylinders) is greatly reduced. Moreover, from the practical point of view, it is difficult to remove the cylinders from the vehicle for requalification testing, and, indeed, the uncharacteristically large size of the cylinders poses problems in terms of locating nearby testing facilities with equipment capable of performing the required hydrostatic test. At the same time, however, in the service for which use of the cylinders would be authorized under the requested exemption it is unlikely that cylinders will be frequently refilled, so that pressure cycling will be low as compared to cylinders used in other services. For all of these reasons, the proposed five year maximum requalification period is considered sufficient to ensure safety in the transport and use of the cylinders under the requested exemption.

*Proposed Operational Controls and Special Provisions.* The operational controls and special provisions proposed herein for incorporation into the requested exemption are consistent with those in DOT-E 8965, and in many other "manufacture, mark, sell and use" exemptions. Therefore, the proposed operational controls and special provisions are considered appropriate for the requested exemption.

*Summary.* For the foregoing reasons, the applicant submits that the proposed packaging requirements and operational controls will provide a level of safety in transport equivalent to that provided by the cylinders authorized under DOT-E 8965 - an exemption which has already been determined by DOT to provide a level of safety at least equivalent to that afforded by the regulations from which exemption is sought.

8. **Request for Emergency Processing.** Pursuant to 49 CFR 107.117(a)(2), the applicant hereby requests this application be accorded emergency processing in order to prevent significant economic loss that could not be prevented if the application were processed on a routine basis. This loss would be borne by Bowgen, and would result from charges and costs passed on to Bowgen by owners of the trailers due to their inability to utilize the trailers for their intended purposes. Depending on the length of time the trailers remain out of service, these charges and costs could total an estimated \$ 500,000 or more. As a family-owned, relatively small business, these costs and charges could materially affect Bowgen's ability to continue to do business, and in the worst case

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could force Bowgen out of business leaving Bowgen's approximately 10 workers without employment.

Apart from the potential for serious economic loss, however, the applicant submits that it would be in the public interest to process this application on an emergency basis. As explained above, the trailers concerned are used to ensure that gas service is maintained to residential customers, small subdivisions, pipelines, businesses and master metered complexes during gas distribution line repairs. Without availability of these trailers, these customers will experience service disruptions often lasting days, and sometimes weeks. Thus, the applicant believes it would be in the public interest to process this application on an emergency basis in order to avoid these service disruptions, and the attendant inconvenience to the affected public.

9. **Conclusion.** In conclusion, for the reasons outlined above the applicant submits that the conditions and limitations proposed in this application for emergency exemption will achieve the necessary level of safety in transport of the hazardous materials concerned. Moreover, for the reasons offered in this application the applicant believes that processing the application on an emergency basis is necessary to avoid significant economic loss to Bowgen, as well as inconvenience to the general public arising from gas service interruptions that could be avoided if the trailers concerned were operational. Accordingly, the applicant respectfully requests that the exemption sought be issued at the earliest possible time.

Please contact the undersigned directly if you have questions concerning this request, or if you require any additional information in order to process this application.

Sincerely,

A handwritten signature in black ink, appearing to read 'E. A. Altemos', with a long horizontal flourish extending to the right.

E. A. Altemos

Enclosures: (1) DOT FRP Standard (§ 178.BB), Revision 1 (January 4, 1987)  
(2) DOT-E 8965, EIGHTH REVISION  
(3) Draft of Paragraph 7.a.. ("PACKAGING") of Requested Exemption

**FRP-2****DOT FRP-2 STANDARD**

DATE: Original: January 15, 1982

Revision 1: January 4, 1987

**BASIC REQUIREMENTS FOR FRP TYPE 3HW COMPOSITE CYLINDERS**

**§ 178.BB Fiber reinforced plastic (FRP) hoop wrapped composite (HWC) cylinders made of definitely prescribed materials.**

**§ 178.BB-1 General.**

Each cylinder must conform with these basic requirements and the specific requirements of the applicable exemption.

**§ 178.BB-2 Type, size and service pressure.**

Type 3HW hoop-wrapped cylinder consisting of resin impregnated continuous filament windings in the circumferential direction only over a seamless aluminum liner made in accordance with § 178.BB-6(a); not over 200 pounds water capacity; and service pressure at least 900 PSI but not greater than 5000 PSI.

**§ 178.BB-3 Inspection by whom and where.**

Inspections and verifications must be performed by an independent inspection agency approved in writing by the Director for the Office of Hazardous Materials Transportation (CHMT), in accordance with 49 CFR 173.300a. Chemical analyses and tests must be made in the United States unless otherwise approved in writing by the Director for CHMT in accordance with 49 CFR 173.300b.

**§ 178.BB-4 Duties of the inspector.**

(a) Determine that all materials conform with the provisions of this standard before releasing them for cylinder manufacture.

(b) Verify that aluminum liner conforms with § 178.BB-6(a). Verify that filament and resin system components conforms with the requirements specified in § 178.BB-5.

(c) Prior to initial shipment of any specific composite cylinder design, verify that the design qualification tests prescribed in § 178.BB-18 have been performed with acceptable results.

(d) Verify that each completed cylinder conforms with all requirements including marking.

(e) Verify that winding process is proper to assure that composite material is uniform, of required thickness and pattern, and in accordance with the composite structure present in cylinders subjected to the design qualification tests.

(f) Witness all tests and pressurizations, obtain copies of all test results and certifications; report volumetric capacity, permanent expansion and completed composite cylinder weight.

(g) Furnish completed inspector's report (§ 178.BB-16) to the maker of the cylinder and upon request, to the purchaser. (See § 178.BB-17).

**§ 178.BB-5 Authorized material and identification of material.**

(a) Aluminum liner must be 6061 or 6351 alloy and T6 temper.

(b) Filament material must be commercial Type-S or commercial Type-E fiberglass. Filaments must be tested in accordance with ASTM D-2343-67 and have minimum strand strength as follows:

(1) Type-S Glass ---- 400,000 PSI.

(2) Type-E Glass ---- 200,000 PSI.

(c) Resin system must be epoxy or modified epoxy type. Resin system must be tested on sample coupons representative of the composite over-wrap in accordance with ASTM D-2344-67 for water boil shear test, and have a minimum shear strength of 5,000 PSI.

(d) Materials must be identified by a suitable method during manufacture.

(e) Materials must be of uniform quality. Materials with injurious defects are not authorized.

**§ 178.BB-6 Manufacture.**

(a) **Liner.** Aluminum liner without over-wrap must be designed for a service pressure of at least 50 percent of the service pressure marked on the composite cylinder, and must conform with DOT 3AL specification (49 CFR 178.46) except:

(1) No marking is to be applied to the cylinder except as specified in § 178.BB-15; and

(2) Hydrostatic test of any cylinder prior to applying filament is not authorized.

(b) **Composite cylinder.** The composite cylinder must be made from an aluminum liner circumferentially wrapped over the entire cylindrical portion with resin impregnated continuous filament winding. Winding pattern must be "hoop" wrap applied under controlled tension to develop the design composite thickness. After winding is complete, the composite must be cured by a controlled temperature profile, and auto-frettagged by pressurizing to not less than 105 percent and not greater than 115 percent of the prescribed minimum test pressure. No defect is acceptable that is likely to weaken the finished cylinder appreciably.



(c) **Welding or brazing.** Welding or brazing for any purpose whatsoever is prohibited.

(d) **Lot size.**

(1) **Liner lot size.** A "liner lot" means a group of cylinders successively produced in one (up to 10 hour) shift having the same:

- (i) size and configuration;
- (ii) specified material of construction;
- (iii) process of manufacture and heat treatment;
- (iv) equipment of manufacture and heat treatment; and
- (v) conditions of time, temperature and atmosphere during heat treatment.

(2) **Composite cylinder lot size.** A "composite cylinder lot" means a group of cylinders successively produced from qualified liners, having:

- (i) the same size and configuration;
- (ii) the same specified materials of construction;
- (iii) the same process of manufacture to the same cylinder specification; and
- (iv) auto-frettagged under the same conditions of time, temperature and pressure.

(3) In no case may the "lot" size exceed 200 units; however, any unit processed for use in the required destructive tests need not be counted as one of the 200, but must have been processed with the lot.

(e) **Design qualification tests.** Prior to initial shipment of any specific cylinder design, qualification tests as prescribed in § 178.88-18 must have been performed with satisfactory results.

**§ 178.88-7 Wall thickness.**

(a) Minimum thickness of the liner must be at least equal to the minimum design thickness and be such that after auto-frettaging, the compressive stress in the sidewall of the liner at zero pressure will not exceed 95 percent of the minimum yield strength of the aluminum as determined in 49 CFR 178.46-13 or 95 percent of the minimum design yield strength shown in § 178.88-18(h). The maximum tensile stress of the liner at operating pressure must not exceed 60 percent of its yield strength.

(b) The maximum filament stress at service pressure must not exceed 40

percent of the filament stress at the virgin burst pressure of the lot test cylinder.

(c) The end design must incorporate added materials to assure the stresses in the areas not supported by the hoop wrap are less than the stresses found in the cylindrical portion.

(d) Stresses shall be computed from Computer Code NASA CF-72124 "Computer Program for the Analysis of Filament-Wound Reinforced Metal Shell Pressure Vessels" May 1966, or other suitable analysis techniques.

#### **§ 178.BB-8 Openings.**

(a) Openings are permitted on the heads only. Centerline of openings must coincide with the longitudinal axis of the cylinder.

(b) Threads are required. Threads must be clean cut, even, without checks and to gauge.

(c) Tapered threads are not permitted.

(d) Any straight thread conforming with National Gas Straight (NGS) thread standard is authorized. The thread must conform with the requirements of Federal Standard (FED-STD) H28-1978. Other straight threads having at least 6 engaged threads are authorized provided that the calculated shear strength is at least 10 times the test pressure of the cylinder.

#### **§ 178.BB-9 Thermal treatment.**

The resin must be cured at the temperature specified and by the process set forth in the cylinder manufacturer's specification and noted in the Inspector's report. Curing temperature and process must correspond with that applied to the cylinders subjected to the qualification tests. The curing temperature must not exceed 350 ° F.

#### **§ 178.BB-10 Pressure relief devices and protection for valves, relief devices, and other connections.**

Pressure relief devices and protection for valves and other connections must conform with 49 CFR 173.34(d) and 173.301(g), except that the adequacy of the pressure relief devices for each design may be verified in accordance with § 178.BB-18(g).

#### **§ 178.BB-11 Nondestructive tests.**

##### **(a) Hydrostatic test.**

(1) By water-jacket, operated so as to obtain accurate data. Pressure gauge must permit reading to accuracy of 1 percent in the range of 80 percent to 120 percent of test pressure. Expansion gauge must permit reading of total expansion to an accuracy of either 1 percent or 0.1 cubic centimeter.

(2) The accuracy of the test equipment must be maintained by periodic recalibration. Records must be maintained to verify that the test equipment is calibrated on a regular basis. A calibration cylinder capable of verifying the equipment accuracy for the material, size and test pressure of the cylinders to be tested must be used for checking the equipment at the beginning of each day.

(3) Pressure must be maintained for 30 seconds and sufficiently longer to insure complete expansion. Any internal pressure applied after auto-fretting and previous to the official test must not exceed 90 percent of the test pressure. If, due to failure of test apparatus, the test pressure can not be maintained, the test may be repeated at a pressure increased by 10 percent or 100 PSI, whichever is lower. Not more than 2 such repeated tests are permitted.

(4) Each cylinder must be tested to at least  $5/3$  times service pressure. In no case may the test pressure exceed the auto-fretting pressure.

#### § 178.88-12 Destructive tests.

(a) **Cycling test.** One cylinder taken at random out of each lot of 200 cylinders or less must be subjected to cyclic pressurization test by hydrostatically pressurizing the cylinder between approximately zero PSI and the designated pressure at a rate not to exceed 4 cycles per minute. Adequate recording instrumentation must be provided if the equipment is to be left unattended for periods of time. All cylinders used in the cycle test must be destroyed.

(b) **Burst test.** One cylinder taken at random out of each lot of 200 cylinders or less shall be hydrostatically pressurized to failure as follows: pressure shall be increased at a uniform rate up to minimum prescribed burst pressure; this pressure to be held for at least 60 seconds; then the pressure shall be further increased to failure. The rate of pressurization must not exceed 200 PSI per second. The cylinder cycle-tested in paragraph (b)(1) above may be used for this burst test.

(c) **Physical test.** Applies to aluminum liner only. If composite cylinder is from DOT 3AL stock, the DOT 3AL required tests may be used for this test.

#### § 178.88-13 Acceptable results of tests.

##### (a) **Hydrostatic test.**

(1) The permanent volumetric expansion of the cylinder must not exceed 5 percent of the total volumetric expansion at test pressure.

(2) All cylinders failing to pass the hydrostatic test must be rejected.

(b) **Physical test.** Applies to aluminum liner only.

(1) Elongation must be at least 14 percent; except that an elongation of 10 percent is acceptable when the authorized specimen size is 24t x 6t.

(2) When the test results fail to meet requirements, the lot must be rejected.

(3) A retest of a rejected lot is authorized if an improper test was made due to the presence of a defect in the specimen or if the equipment or procedure was faulty. The retest must be performed on specimens taken from the same cylinder liner.

**(c) Cycling test.**

(1) Each test cylinder must withstand at least 10,000 pressurizations between approximately zero and service pressure followed by at least 30 pressurizations between zero and test pressure, without evidence of distortion or failure.

(2) When the test cylinder fails to withstand the cycle test, the lot represented must be rejected.

**(d) Burst test.**

(1) Burst pressure shall be at least 2-1/2 times the service pressure and in no case less than the value necessary to meet the stress criteria of § 178.BB-7(a). Failure must initiate in the cylinder sidewall. Cylinders with marked service pressure not exceeding 2,200 PSI must remain in one piece. Actual burst pressure must be recorded.

(2) When the test cylinder fails to withstand the minimum prescribed burst pressure, the lot represented must be rejected.

**§ 178.BB-14 Rejected liners and cylinders.**

(a) **Physical test.** Reheat treatment of aluminum liners that failed the physical test is authorized. Subsequent thereto, acceptable liners must pass all prescribed tests.

(b) **Hydrostatic test.** Cylinders rejected by the hydrostatic test must not be placed in service.

(c) **Cycle test.** Cylinders of lots rejected by the cycle test must not be placed in service.

(d) **Burst test.** Cylinders of lots rejected by the burst test must not be placed in service.

**§ 178.BB-15 Marking.**

(a) Each cylinder must be permanently marked by a method other than stamping in the composite wrap on the side near the end of the cylinder

containing the valve outlet.

(b) Required markings are as follows:

(1) DOT-E \*\*\*\*-YYY (where \*\*\*\* = Exemption number and YYY = service pressure in PSIG).

(2) A serial number and an identifying symbol (letters); location of serial number to be just below or immediately following the DOT mark; location of symbol to be just below or immediately following the serial number. The symbol and serial number must be those of the maker. The symbol must be registered with the Director for QMT; duplications not authorized.

(3) The Inspector's official mark must be placed near the serial number.

(4) Date of test (month and year).

(5) Examples of cylinder marking:

DOT-E \*\*\*\*-2000 or: DOT-E \*\*\*\*-2000-1234-XY-AB-3-81  
1234-XY  
AB  
3-81

(c) Size of marks must be at least 1/4 inch high if space permits.

(d) Additional markings are permitted in the composite, or may be stamped in low stress areas of the aluminum liner, other than the sidewall, provided the markings are not of a size and depth that will create harmful stress concentrations.

(e) Retest dates may be stamped in low stress areas of the top head. [Should be transferred to 49 CFR 173.34(e) at rulemaking.]

§178.88-16 Inspector's report.

(a) The inspector must prepare a report that is clear, legible and in accordance with the following:

**REPORT OF MANUFACTURE OF FIBER REINFORCED PLASTIC (FRP) 3HV HOOP  
WRAPPED COMPOSITE (HW) ALUMINUM LINED COMPRESSED GAS CYLINDER.**

(Place) \_\_\_\_\_  
 (Date) \_\_\_\_\_  
 (Exemption number) \_\_\_\_\_  
 Manufactured for \_\_\_\_\_  
 Located at \_\_\_\_\_  
 Manufactured by \_\_\_\_\_  
 Located at \_\_\_\_\_  
 Consigned to \_\_\_\_\_  
 Located at \_\_\_\_\_  
 Quantity \_\_\_\_\_ Size \_\_\_\_\_ inches outside diameter by \_\_\_\_\_ inches long  
 Marks placed on the \_\_\_\_\_ of the cylinder are:  
 DOT-E \_\_\_\_\_  
 Serial numbers \_\_\_\_\_ to \_\_\_\_\_ inclusive.  
 Identifying symbol (Registered) \_\_\_\_\_  
 Inspector's mark (Registered) \_\_\_\_\_  
 Test date(s) \_\_\_\_\_  
 Other marks (if any) \_\_\_\_\_

Each composite cylinder was made by circumferentially overwrapping a seamless aluminum liner with resin impregnated continuous filament reinforcement. Composite overwrap was made by winding resin impregnated continuous filament over this liner in the circumferential direction only, followed by curing the resin at controlled temperature. The liner conforms with § 178.BB-6(a) for unwrapped cylinders having a service pressure of \_\_\_\_\_ PSIG. Conformance of the liner with § 178.BB-6(a) was verified by performance of the prescribed tests or by obtaining the report of the inspector performing the prescribed tests.

Filament and resin were certified by the manufacturer and identified by package number. Strand strength of filament was verified. Shear strength of composite was verified. After wrapping, composite was cured per manufacturers's specification.

Prescribed auto-fretage and hydrostatic tests were made in the presence of the inspector. All cylinders accepted conform with the specification requirements.

Tensile stress on the aluminum liner is calculated to be \_\_\_\_\_ PSI at service pressure. Filament stress is calculated to be \_\_\_\_\_ PSI at service pressure.

I hereby certify that all of these cylinders proved satisfactory in every way and conform with the requirements of DOT-E \_\_\_\_\_; except as follows:

Exceptions taken to any reporting or testing requirements of this exemption are: \_\_\_\_\_

\_\_\_\_\_  
 (Signed) \_\_\_\_\_  
 (Inspector)

#### RECORD OF CHEMICAL ANALYSES OF MATERIAL FOR LINER

Place \_\_\_\_\_

Date \_\_\_\_\_  
 Exemption number \_\_\_\_\_  
 Serial numbers \_\_\_\_\_ to \_\_\_\_\_ inclusive.  
 Size \_\_\_\_\_ inches outside diameter by \_\_\_\_\_ inches long.  
 Made by \_\_\_\_\_ Company.  
 For \_\_\_\_\_ Company.  
 Material description \_\_\_\_\_

NOTE: Any omission of analyses by heats, if authorized, must be accounted for by notation herein reading "The prescribed certificate of the manufacturer of material has been secured, found satisfactory, and placed on file." or by attaching a copy of the certificate.

Alloy Designation	Cylinders Represented (Serial Nbs.)	Chemical analyses									
		Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Others Ea.	Total Al.
_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____	_____

Material was manufactured and mill analyses made by \_\_\_\_\_  
 Originals of the certified mill analyses reports are in files of the material manufacturer.

(Signed) \_\_\_\_\_  
 (Inspector)

#### RECORD OF PHYSICAL TESTS OF MATERIAL FOR LINERS.

Place \_\_\_\_\_  
 Date \_\_\_\_\_  
 Exemption Number \_\_\_\_\_  
 Serial numbers \_\_\_\_\_ to \_\_\_\_\_ inclusive.  
 Size \_\_\_\_\_ inches outside diameter by \_\_\_\_\_ inches long.  
 Made by \_\_\_\_\_ Company.  
 For \_\_\_\_\_ Company.  
 Test specimen description \_\_\_\_\_

Lot Code	Cylinders Represented by Test. (Serial Nbs)	Yield Strength at 0.2 percent Offset (pounds per square inch)	Tensile Strength (pounds per square inch)	Elongation (percent)
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

(Signed) \_\_\_\_\_  
 (Inspector)

#### REPORT OF COMPOSITE ANALYSES

Place \_\_\_\_\_

Date \_\_\_\_\_  
 Exemption number \_\_\_\_\_  
 Materials \_\_\_\_\_  
 Manufactured by \_\_\_\_\_ Company.  
 For \_\_\_\_\_ Company.  
 Numbered \_\_\_\_\_  
 Filament specification and designation \_\_\_\_\_  
 Manufactured by \_\_\_\_\_

Manufacturing package number	Tensile strength	Inter-laminar shear strength

**RESIN SYSTEM COMPONENTS  
MANUFACTURING BATCH NUMBERS**

Resin		Curing agent		Accelerator	
Batch number	Type	Batch number	Type	Batch number	Type

Signed \_\_\_\_\_  
Inspector

**REPORT OF HYDROSTATIC TEST FOR FRP TYPE 3HW CYLINDERS**

Place \_\_\_\_\_



Date \_\_\_\_\_  
 Exemption number \_\_\_\_\_  
 Manufactured by \_\_\_\_\_  
 Located at \_\_\_\_\_  
 Manufactured for \_\_\_\_\_  
 Located at \_\_\_\_\_  
 Serial numbers \_\_\_\_\_ to \_\_\_\_\_ inclusive.  
 Symbol \_\_\_\_\_  
 Minimum prescribed test pressure \_\_\_\_\_ psig.

Weight - pounds (without valve)				Hydrostatic test				
Serial number	Compo- Liner site	Total	Volume cu.in	Auto- fretage pressure psig	Total expan- sion cu.in	Perma- nent expan- sion cu.in	Ratio of PE to TE percent	Actual test pres- sure psig

#### LOT CYCLING AND BURST TESTS

Type of test	Serial Number of cylinder	Number of pressurizations to service pressure	to test pressure	Burst pressure (psig)
Cycling				
Virgin				
Burst				

§ 178.BB-17 Retention of inspector's report.

The inspector's report (§ 178.BB-16) must be retained for 15 years from

the original test date on the cylinder by the maker and the inspector.

**§ 178.88-18 Design qualification tests.**

(a) **General.** Except as authorized in § 178.88-10(a), qualification tests as prescribed in this paragraph shall have been performed on representative cylinders of each specific design prior to any initial shipment. All cylinders used for design qualification tests must be fabricated on the same equipment and subjected to the same processes as is used to produce cylinders intended for charging and shipment. All tests must be witnessed by an independent inspector. Test reports must be kept on file by the cylinder maker and made available to the independent inspector and the CHMT upon request.

(b) **Design changes.** For purposes of this standard, a design change is:

- (1) any change in material;
- (2) a 10 percent or greater change in diameter or service pressure; or
- (3) a 30 percent or greater change in water capacity.

(c) **Test requirements.** Each cylinder design or any design change to an approved cylinder design must be qualified by subjecting representative cylinders to the tests prescribed in the following table:

Type of test	ORIGINAL DESIGN		DESIGN CHANGE			
			Diameter or			
			Material Service pressure Water capacity			
			Any change	10 to 20 percent change	Greater than 20 percent change	Greater than 50 percent change
Cycling-Ambient	X	X	X	X	X	X
Cycling-Environmental	X	X	-	X	-	X
Cycling-Thermal	X	X	-	X	-	X
Hydraulic burst	X	X	X	X	X	X
Gunfire	X	X	X	X	X	X
Bonfire	X	X	X	X	X	X

(d) **Pressure cycling tests.** All cycling tests shall be performed by hydrostatically pressurizing the cylinder between approximately zero and

designated pressure at a rate not in excess of 4 cycles per minute. All cylinders used in cycle tests must be destroyed. Adequate recording instrumentation must be provided if equipment is to be left unattended for periods of time.

(1) **Cycling test at ambient temperature.** One representative cylinder shall be cycle tested at ambient temperature without showing evidence of distortion, deterioration or failure, as follows: pressurize from approximately zero to service pressure for 10,000 cycles; then pressurize from approximately zero to test pressure for 30 cycles. After successfully passing this test the cylinder must be pressurized to burst in accordance with paragraph (e)(1) of this section and the burst pressure recorded.

(2) **Environmental cycling test.** One representative cylinder free of any protective coating shall be cycle tested without showing evidence of distortion, deterioration or failure as follows. Any cylinder subjected to this cycling test must be destroyed.

(i) Condition the cylinder for 48 hours at zero pressure, 140 °F. or higher and 95 percent or greater relative humidity.

(ii) Pressurize from zero to service pressure for 5,000 cycles at 140 ° F. or higher and 95 percent or greater relative humidity.

(iii) Stabilize at zero pressure and ambient conditions.

(iv) Then pressurize from zero to service pressure for 5,000 cycles at -60 ° F. or lower.

(v) Stabilize at zero pressure and ambient temperature conditions.

(vi) Then pressurize from zero to test pressure for 30 cycles at ambient temperature.

(3) **Thermal cycling test.** One representative cylinder shall be tested without showing evidence of distortion, deterioration or failure as follows:

(i) Cycle test at ambient temperature by performing 10,000 pressurizations from approximately zero to service pressure and 30 pressurizations from zero to test pressure.

(ii) Then hydrostatically pressurize to service pressure; and submerge the pressurized cylinder in 200 ° F fluid, soak for 10 minutes; transfer and submerge in -60 ° F fluid and soak for 10 minutes. Subject cylinder to 20 such cycles restricting the transfer time to at least one minute but not more than 3 minutes. The pressure in the cylinder may be controlled so that it does not exceed test pressure nor less than marked service pressure.

(4) After successfully passing this test, the cylinder must be pressurized to burst in accordance with paragraph (e)(1) of this section and burst pressure recorded.

(e) **Hydraulic burst test.**

(1) One representative cylinder shall be hydrostatically pressurized to failure as follows: pressure shall be increased at a uniform rate up to minimum prescribed burst pressure; this pressure to be held for at least 60 seconds; then pressure will be further increased to failure. The pressurization rate throughout the test must not exceed 200 psi per second.

(2) Burst pressure must be at least 2.5 times the marked service pressure, and in no case less than the value necessary to meet the stress criteria of § 178.88-7(b). Failure must initiate in the sidewall. Cylinders with marked service pressure not exceeding 2200 psi must remain in one piece. Actual burst pressure must be recorded.

(f) **Gunfire Test.** One representative cylinder charged with air or nitrogen to service pressure shall be impacted by a 0.30 caliber armor-piercing projectile having a velocity of approximately 2800 feet per second. The cylinder shall be positioned so that the projectile impact point is in the cylinder sidewall having hoop winding, at approximately 45 degree angle and aimed to exit at the cylinder sidewall. Distance from firing location to test cylinder must not exceed 50 yards. Tested cylinder shall reveal no evidence of fragmentation failure. Approximate size of entrance and exit openings must be recorded.

(g) **Bonfire test.** Test cylinders must be fitted with pressure relief devices in accordance with §178.88-10 and charged with the intended lading to the prescribed filling pressure or density. Charging with nitrogen or air to service pressure is authorized only if cylinders are to be charged only with non-liquefied gases. Fire for test shall be generated by kerosine-soaked wood, gasoline or JP-4 fuel. The lowest part of the cylinder shall be approximately 4 inches above the base of the fire when wood fire is used or shall be approximately 4 inches above the liquid surface if gasoline or JP-4 fuel is used. Test cylinder shall be exposed to fire until completely vented. Time-pressure readings must be recorded at 30 second intervals from start of fire until venting is completed. Test results are not acceptable if contents vent from any location other than through a pressure relief device. After successfully passing the fire test, each cylinder must be pressurized to burst and burst pressure recorded. Tests must be performed as follows:

(1) **Vertical test.** Place test cylinder in its upright position and subject to total fire engulfment but in no case shall the flame be allowed to impinge directly on any relief device. Shielding of pressure relief devices with a metal plate may be used but is not a requirement. For cylinders equipped with relief devices on both ends, the bottom relief devices must be shielded from any flame impingement.

(2) **Horizontal tests.** Place test cylinder in its upright position and subject the entire length to flame impingement except that the flame must not be allowed to impinge directly on any relief device. Shielding of the pressure relief devices with a metal plate may be used but is not a requirement.

(3) **Cylinders for liquified gas service.** At least one representative cylinder must be subjected to the horizontal test and two to the vertical test.

(4) **Cylinders for non-liquefied gas service only.** At least 2 cylinders must be subjected to the vertical test. Horizontal test is not required.

(i) **Qualification test results.** A report of all tests for each design qualification, describing test setup, procedure and results must be submitted to the CHMT. This report must include at least the following basic information on each cylinder design tested.

### BASIC CYLINDER DESIGN INFORMATION

#### Dimension, material and pressure data.

(Date) .....	_____	
(Exemption number) .....	_____	
Service pressure .....	_____	PSIG
Auto-fretage pressure (Note 1) .....	_____	PSIG
Test pressure .....	_____	PSIG
Minimum prescribed burst pressure .....	_____	PSIG
Calculated burst pressure .....	_____	PSIG
Volume .....	_____	cu. in.
Inside diameter .....	_____	inches
Outside diameter of cylinder .....	_____	inches
Liner material and temper ...	_____	
Filament material .....	_____	
Resin material .....	_____	
Total weight of cylinder .....	_____	pounds
Weight of liner .....	_____	pounds
Weight of composite material .....	_____	pounds
Minimum wall thickness of liner (Qual. test cyl) .....	_____	inch
Minimum design wall thickness of liner .....	_____	inch
Yield strength of liner (Qual. test cyl) .....	_____	psi
Minimum design yield strength of liner .....	_____	psi
Nominal thickness of overwrap .....	_____	inch
Minimum strand strength of filament .....	_____	psi
Minimum shear strength of resin .....	_____	psi

Note 1. For each qualification test cylinder, the total and permanent volumetric expansion readings obtained in the auto-fretage pressurizations must be recorded.

**DESIGN STRESSES AND LOAD DISTRIBUTION**

	S T R E S S		L O A D	
	Direction	Distribution (psi)	Distribution (%)	
Pressure	Long. Circ.	Liner Overwrap	Liner Overwrap	
	X	-	-	
Zero	-	X	-	
	X	-	-	
Service	-	X	-	
	X	-	-	
Test	-	X	-	
*Minimum	X	-	-	
Burst	-	X	-	

\*Based on §178.BB-7



U.S. Department  
of Transportation  
**Research and  
Special Programs  
Administration**

400 Seventh St., S.W.  
Washington, D.C. 20590

DOT-E 8965  
(EIGHTH REVISION)

**MAR 8 2002**

**EXPIRATION DATE: February 29, 2004**

(FOR RENEWAL, SEE 49 CFR § 107.109)

1. **GRANTEE:** Pressed Steel Tank Company, Inc.  
Milwaukee, WI
2. **PURPOSE AND LIMITATIONS:**
  - a. This exemption authorizes the manufacture, mark, sale and use of non-DOT specification fiber reinforced plastic, hoop wrapped cylinder for use in the transportation of Division 2.1 and 2.2 hazardous materials described in paragraph 6 below. This exemption provides no relief from any Hazardous Materials Regulation other than as specifically stated herein.
  - b. The safety analyses performed in development of this exemption only considered the hazards and risks associated with transportation in commerce.
3. **REGULATORY SYSTEM AFFECTED:** 49 CFR Parts 106, 107 and 171-180.
4. **REGULATIONS FROM WHICH EXEMPTED:** 49 CFR §§ 173.302(a) and 175.3, except as specified herein.
5. **BASIS:** This exemption is based on the application of Pressed Steel Tank Company dated February 21, 2002, submitted in accordance with § 107.109 and additional information dated March 7, 2002.
6. **HAZARDOUS MATERIALS (49 CFR § 172.101):**

Proper Shipping Name/ Hazardous Material Description	Hazard Class/ Division	Identi- fication Number	Packing Group
Air, compressed	2.2	UN1002	N/A
Argon, compressed	2.2	UN1006	N/A
Helium, compressed	2.2	UN1046	N/A

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Proper Shipping Name/ Hazardous Material Description	Hazard Class/ Division	Identi- fication Number	Packing Group
Hydrogen, compressed	2.1	UN1049	N/A
Methane, compressed or Natural gas, compressed (with high methane content)	2.1	UN1971	N/A
Nitrogen, compressed	2.2	UN1066	N/A
Oxygen, compressed	2.2	UN1072	N/A

7. SAFETY CONTROL MEASURES:

a. PACKAGING - Packaging prescribed is a non-DOT specification fiber reinforced plastic (FRP) hoop wrapped (HW) cylinder made in accordance with Pressed Steel Tank's specification presented with their petition on file with the Office of Hazardous Materials Exemptions and Approvals (OHMEA), and in full compliance with DOT FRP-2 Standard (See Appendix I) Revision 1 dated January 4, 1987 (§ 178.BB) except as follows:

§ 178.BB.-2 Type size and service pressure. Type 3HW cylinder consisting of resin impregnated continuous filament windings in the circumferential direction only over a seamless steel liner made in compliance with 178.BB-6(a); not over 400 pounds water capacity; and service pressure at least 900 PSI but not greater than 5000 PSI. The maximum steel liner sidewall thickness must not exceed 0.500 inches.

§ 178.BB-4 Duties of Inspector.

(a) \* \* \*

(b) Verify compliance of steel liner with § 178.BB-6(a). Verify compliance of filament and resin system components with the requirements specified in § 178.BB-5.

\* \* \* \* \*

§ 178.BB-5 Authorized material and identification of material.

(a) Liner material must be as prescribed in § 178.37(b).



\* \* \* \* \*

§ 178.BB-6 Manufacture.

(a) Liner. Liner without overwrap must be suitable for a marked service pressure of at least 50 percent of the service pressure marked on the composite cylinder, and must be in full compliance with DOT 3AA (§ 178.37) except as follows:

(1) The design is required to be in compliance with § 178.37(a)(2).

\* \* \* \* \*

(b) Composite Cylinder. The composite cylinder must be fabricated from a steel liner circumferentially wrapped over the entire cylindrical portion with resin impregnated continuous filament windings. Winding pattern to be "hoop" wrap, applied under controlled tension to develop the design composite thickness. After winding is complete, the composite must be cured by a controlled temperature profile, and autofrettaged by pressurizing to not less than 105 and not greater than 115 percent of the prescribed minimum test pressure. No defect is acceptable that is likely to weaken the finished cylinder appreciably.

\* \* \* \* \*

§ 178.BB-7 Wall thickness.

(a) Minimum thickness of the liner must be at least equal to the minimum design thickness (§ 178.BB-18 (h)) and be such that after autofrettage, the compressive stress in the sidewall of the liner at zero pressure will not exceed 50 percent of the minimum yield strength of the steel as determined in § 178.37(k) or 50 percent of the minimum design yield strength shown in § 178.BB-18 (h). The maximum tensile stress of the liner at operating pressure may not exceed 60% of the yield strength.

\* \* \* \* \*

§ 178.BB-8 Openings.

(a) and (b) \* \* \*

MAR 8 2002

(c) Taper threads when used must comply with one of the following:

(1) American Standard Pipe Thread (NPT) standard must comply with the requirements of Federal Standard H 28/7 (1978).

(2) National Gas Taper Thread (NGT) Standard must comply with the requirements of Federal Standard H 28/7 and H 28/9 (1978).

§ 178.BB-12 Destructive tests.

(a) Applies except change cycling rate to "10 cycles per minute".

\* \* \* \* \*

§ 178.BB-13 Acceptable results of tests.

(a) \* \* \*

(b) Physical test. Applies to steel liner only.

(1) Elongation must be at least 20 percent for 2 inch gauge length or at least 10 percent in other cases.

(2) \* \* \*

(3) \* \* \*

(c) Cycling test.

(1) Each test cylinder must withstand at least 10,000 pressurizations between approximately zero and service pressure, without evidence of distortion or failure.

(d) Burst test.

(1) Burst pressure must be at least 2-1/2 times the service pressure and in no case less than the value necessary to meet the stress criteria of § 178.BB-7(b). Failure must initiate in the cylinder sidewall. Cylinders with marked service pressure not exceeding 2200 psi must remain in one piece. Actual burst pressure must be recorded.

(2) \* \* \*

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§ 178.BB-14, § 178.BB-15, and § 178.BB-16

Change "aluminum" to "steel" whenever the word aluminum is found in these paragraphs.

\* \* \* \* \*

§ 178.BB-18 Design qualification tests.

(a) thru (c) • \* \*

(d) \* \* \* Except change cycling rate to "10 cycles per minute".

(1) and (2) \* \* \*

(3) Not required.

(e) \* \* \*

(1) \* \* \*

(2) See § 178.BB-13(d) (1) of this exemption.

(f) Not required

\* \* \* \* \*

b. TESTING -

Each cylinder must be reinspected and hydrostatically retested every three years in accordance with § 173.34(e) as prescribed for DOT 3HT cylinders, except that the rejection elastic expansion criteria does not apply, permanent volumetric expansion may not exceed 5 percent of total volumetric expansion at test pressure and retest dates must be imbedded in the epoxy coating in a permanent manner other than stamping. Retest dates may be steel stamped on the shoulder of the top head in accordance with § 178.BB-15(d). Reheat treatment or repair of rejected cylinders not authorized.

c. OPERATIONAL CONTROLS -

Cylinders manufactured under this exemption are not authorized for use 15 years from the date of manufacture.

8. SPECIAL PROVISIONS:

a. In accordance with the provisions of Paragraph (b) of § 173.22a, persons may use the packaging authorized by this exemption for the transportation of the hazardous materials specified in paragraph 6, only in conformance with the terms of this exemption.

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- b. A person who is not a holder of this exemption, but receives a package covered by this exemption, may reoffer it for transportation provided no modifications or changes are made to the package and it is offered for transportation in conformance with this exemption and the HMR.
  - c. A current copy of this exemption must be maintained at each facility where the package is offered or reoffered for transportation.
  - d. Each packaging manufactured under the authority of this exemption must be marked with a registration symbol designated by the Office of Hazardous Materials Exemptions and Approvals for a specific manufacturing facility.
  - e. A current copy of this exemption must be maintained at each facility where the package is manufactured under this exemption. It must be made available to a DOT representative upon request.
  - f. Use of these cylinders for underwater breathing is not authorized.
  - g. A cylinder which has been subjected to the action of fire may not be returned to service.
  - h. The special filling provisions in § 173.302(c) are not authorized.
  - i. Prototype cylinders to be used solely for design qualification testing may be charged and shipped from the filling facility to the test site, provided each cylinder is in conformance with the provisions of this exemption except for marking (§ 178.BB-15) and design qualification testing (§ 178.BB-18).
  - j. Transportation of Division 2.1 materials (flammable gases) by passenger-carrying aircraft is not authorized.
  - k. Transportation of Division 2.1 materials (flammable gases) are not authorized aboard cargo vessel or cargo aircraft unless specifically authorized in the Hazardous Materials Table (§ 172.101).
9. MODES OF TRANSPORTATION AUTHORIZED: Motor vehicle, rail freight, cargo vessel, cargo aircraft only, and passenger-carrying aircraft (see paragraphs 8.j. and 8.k. for restrictions).

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10. MODAL REQUIREMENTS:

a. A current copy of this exemption must be carried aboard each cargo vessel, aircraft or motor vehicle used to transport packages covered by this exemption. The shipper must furnish a current copy of this exemption to the air carrier before or at the time the shipment is tendered.

b. Flammable Gases are not authorized to be transported aboard passenger-carrying aircraft.

11. COMPLIANCE: Failure by a person to comply with any of the following may result in suspension or revocation of this exemption and penalties prescribed by the Federal hazardous materials transportation law, 49 U.S.C. 5101 et seq:

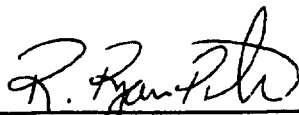
- o All terms and conditions prescribed in this exemption and the Hazardous Materials Regulations, Parts 171-180.
- o Registration required by § 107.601 et seq., when applicable.

Each "Hazmat employee", as defined in § 171.8, who performs a function subject to this exemption must receive training on the requirements and conditions of this exemption in addition to the training required by §§ 172.700 through 172.704.

No person may use or apply this exemption, including display of its number, when the exemption has expired or is otherwise no longer in effect.

12. REPORTING REQUIREMENTS: The carrier is required to report any incident involving loss of packaging contents or packaging failure to the Associate Administrator for Hazardous Materials Safety (AAHMS) as soon as practicable. (Sections 171.15 and 171.16 apply to any activity undertaken under the authority of this exemption.) In addition, the holder(s) of this exemption must also inform the AAHMS, in writing, as soon as practicable of any incidents involving the package and shipments made under this exemption.

Issued in Washington, D.C.



for Robert A. McGuire  
Associate Administrator for  
Hazardous Materials Safety

MAR 8 2002

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(DATE)

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Address all inquiries to: Associate Administrator for Hazardous Materials Safety, Research and Special Programs Administration, Department of Transportation, Washington, D.C. 20590.  
Attention: DHM-31.

Copies of this exemption may be obtained by accessing the Hazardous Materials Safety Homepage at <http://hazmat.dot.gov/exemptions> Photo reproductions and legible reductions of this exemption are permitted. Any alteration of this exemption is prohibited.

PO: sln

**Draft of Text of Paragraph 7.a. (“Packaging”) of Requested Exemption  
Based on Requirements Proposed in  
Bowgen Fuel Systems Emergency Exemption Application**

7. **SAFETY CONTROL MEASURES:**

a. **PACKAGING** - Packaging prescribed is a motor vehicle (trailer) with horizontally mounted and secured, manifolded, non-DOT specification fibre reinforced plastic hoop wrapped cylinders meeting the following requirements:

(1) Cylinders. Cylinders authorized are non-DOT specification fiber reinforced plastic (FRP) hoop wrapped (HW) cylinders manufactured by Pressed Steel Tank Company, Inc., of Milwaukee Wisconsin, and complying with DOT FRP-2 Standard, Revision 1, dated January 4, 1987 (§ 178.BB) except as follows:

§ 178.BB-2 **Type, size and service pressure.** Type 3HW cylinder consisting of resin impregnated continuous filament windings in the circumferential direction only over a seamless steel liner made in compliance with 178.BB-6(a); not over 400 pounds water capacity; and service pressure at least 900 PSI but not greater than 5000 PSI. The maximum steel liner sidewall thickness must not exceed 0.500 inches.

§ 178.BB-3 **Inspection by whom and where.** Inspections and verifications must be performed by an independent inspection agency approved in writing by the Associate Administrator for Hazardous Materials Regulation in accordance with Subpart I of 49 CFR Part 107. Chemical analyses and tests must be made in the United States, except that chemical analyses for steel manufactured in Canada may be verified by the independent inspection agency on the basis of the manufacturer’s ladle analysis.

§ 178.BB-4 **Duties of Inspector.**

(a) \* \* \*

(b) Verify compliance of steel liner with § 178.BB-6(a). Verify compliance of filament and resin system components with the requirements specified in § 178.BB-5.

\* \* \* \* \*

§ 178.BB-5 Authorized material and identification of material.

(a) Liner material must be as prescribed in § 178.37(b).

\* \* \* \* \*

§ 178.BB-6 Manufacture.

(a) Liner. Liner without overwrap must be suitable for marked service pressure of at least 47.7 percent of the service pressure marked on the composite cylinder, and must be in full compliance with DOT 3AA (§ 178.37) except as follows:

(1) The design is required to be in compliance with § 178.37(a)(2).

(2) \* \* \*

(3) The flattening test in § 178.37(j) is not required.

(b) Composite cylinder. The composite cylinder must be fabricated from a steel liner circumferentially wrapped over the entire cylindrical portion with resin impregnated continuous filament windings. Winding pattern to be “hoop” wrap, applied under controlled tension to develop the design composite thickness. After winding is complete, the composite must be cured by a controlled temperature profile, and autofrettaged by pressurizing to not less than 105 percent and not greater than 125 percent of the prescribed minimum test pressure. No defect is acceptable that is likely to weaken the finished cylinder appreciably.

\* \* \* \* \*



(d) Lot size. Applies, except add “(other than length)” following “size and configuration” wherever it appears.

\* \* \* \* \*

§ 178.BB-7 Wall thickness.

(a) Minimum thickness of the liner must be at least equal to the minimum design thickness (§ 178.BB-18(h)) and be such that after autofrettage, the compressive stress in the sidewall of the liner at zero pressure will not exceed 50 percent of the minimum yield strength of the steel as determined in § 178.37(k) or 50 percent of the minimum design yield strength shown in § 178.BB-18(h). The maximum tensile stress of the liner at operating pressure may not exceed 60 percent of the yield strength.

\* \* \* \* \*

§ 178.BB-8 Openings.

(a) and (b) \* \* \*

(c) Taper threads when used must comply with one of the following:

(1) American Standard Pipe Thread (NPT) standard must comply with the requirements of Federal Standard H 28/7 (1978)

(2) National Gas Taper Thread (NGT) Standard must comply with the requirements of Federal Standard H 28/7 and H 28/9 (1978).

\* \* \* \* \*

§ 178.BB-11 Nondestructive tests.

(a) \* \* \*

- (b) Ultrasonic test. The entire wall (i.e., 100 percent) of each cylinder must be ultrasonically tested.

§ 178.BB-12 Destructive tests.

- (a) Applies except change cycle rate to “10 cycles per minute”.
- (b) Applies except delete “this pressure to be held for 60 seconds”.

\* \* \* \* \*

§ 178.BB-13 Acceptable results of tests.

- (a) \* \* \*

- (b) Physical test. Applies to steel liner only.

- (1) Elongation must be at least 20 percent for 2 inch gauge length or at least 10 percent in other cases.

- (2) \* \* \*

- (3) \* \* \*

- (4) Charpy impact value at -40°F must be not less than 44 J/cm<sup>2</sup>.

- (c) Cycling test.

- (1) Each test cylinder must withstand at least 5,000 pressurizations between approximately zero and 1.25 times the service pressure, without evidence of distortion or failure.

- (2) \* \* \*

(d) Burst test.

(1) Burst pressure must be at least 2-1/2 times the service pressure and in no case less than the value necessary to meet the stress criteria of § 178.BB-7(b). Failure must initiate in the cylinder sidewall. Cylinders with marked service pressure not exceeding 2200 psi must remain in one piece. Actual burst pressure must be recorded.

(2) \* \* \*

(e) Ultrasonic test. In no case may the notch size of any longitudinal defect exceed 0.015 inches deep by 0.75 inches long, or for any transverse defect exceed 0.025 inches deep by 0.75 inches long.

§ 178.BB-14 Rejected cylinders and liners. Change “aluminum” to “steel” wherever the word aluminum is found in this paragraph.

§ 178.BB-15 Marking.

(a) \* \* \*

(b) Applies, except the DOT exemption number is not required.

(c) \* \* \*

(d) Applies, except change “aluminum” to “steel” where the word aluminum is found in this paragraph.

(e) \* \* \*

§ 178.BB-16 Inspector's report. Inspector's report must conform to the requirements of ANSI Standard NGV2 - 2000 (“Basic Requirements for Compressed natural gas Vehicle Fuel Containers”).

\* \* \* \* \*

§ 178.BB-18 Design qualification tests.

(a) \* \* \*

(b) \* \* \*

(1) \* \* \*

(2) a 20 percent or greater change in diameter or a 10 percent or greater change in service pressure; or

(3) \* \* \*

(c) \* \* \*

(d) \* \* \*

(1) Cycling test at ambient temperature. One representative cylinder shall be cycle tested at ambient temperature without showing evidence of distortion, deterioration or failure, as follows: pressurize from approximately zero to 1.25 times service pressure for 5,000 cycles; then pressurize from approximately zero to service pressure for 13,000 cycles. After successfully passing this test the cylinder must be pressurized (cycled) from approximately zero to 1.25 times service pressure until the cylinder fails. Failure must be by leakage rather than burst, and the failure pressure must be recorded.

(2) Applies except change “-60° F” to “-40°F”

(3) Not required.

(e) Hydraulic burst test.

(1) Applies except delete “this pressure to be held for 60 seconds”.

(2) See § 178.BB-13(d)(1) of this exemption.

(f) Not required.

\* \* \* \* \*

(2) *Motor vehicle (trailer).* Authorized cylinders must be horizontally mounted on a motor vehicle (trailer), secured, manifolded together, and valves and pressure relief devices protected, in conformance with all applicable requirements in § 173.301(g)(1).